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Olfactory conditioning during the recruitment process in a leaf-cutting ant

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Summary. During recruitment, workers of *Acromyrmex lundi* are conditioned to the odor of the food fragment initially carried by the scout worker. The learned odor cue is used as a decision criterion during food collection.

Key words: Ants – *Acromyrmex lundi* – Conditioning – Recruitment – Foraging

Leaf-cutting ants are highly polyphagous Neotropical herbivores that use several plant species as substrates on which they culture a fungus garden. A number of (not mutually exclusive) factors have been suggested as criteria by which foraging ants decide to accept or reject a particular plant: leaf nutritional value (Rockwood 1976), leaf physical features (Cherrett 1972; Waller 1982), leaf water content (Bowers and Porter 1981), and plant secondary chemicals (Cherrett 1972; Howard 1987, 1988). These factors are expected to influence the decisions of scout workers which initiate the recruitment process.

In this paper the first evidence of conditioning to the food odor during recruitment in ants is presented: recruited workers of the leaf-cutting ant *Acromyrmex lundi* G. use the food odor as a learned cue to make a decision during foraging.

Materials and methods

Assays were carried out on a laboratory colony of the leaf-cutting ant *Acromyrmex lundi*. Workers were allowed to collect fungal substrate (corn or wheat germ flakes) at a foraging table 70 cm from the nest, connected to the nest table by a wooden bridge.

Conditioning assays were initiated by placing a patch of odor-impregnated flakes on the foraging table. They were impregnated with one of the following commercial essences: vanilla, peppermint, orange, coconut, almond, or lemon blossom water. When a scout worker encountered the flakes, it would pick one up and run back to the nest, displaying recruiting behaviors, as described for the leaf-cutting ant *Atta cephalotes* (Jaffé and Howse 1979). Immediately after a scout picked up a flake and ran towards the nest, the flakes were removed and replaced by 20 impregnated filter paper disks (5 mm diameter) distributed randomly in a grid pattern about 1.5 cm apart: 10 disks were impregnated with the same odor as the flakes (*positive* disks) and 10 with another odor (*negative* disks). Random number sequences were used to select the odor pair for each assay and to assign the positive and the negative odor. Disks were identified by pencilled marks on both sides. Each recruited worker arriving at the foraging table encountered the paper disks instead of the flakes, and immediately picked one up. For each assay, the sign (positive or negative) of the first 10 disks picked up was recorded. Ten conditioning assays were performed, totaling 100 pick-up events.

Control assays were similar to conditioning assays except that unimpregnated flakes were used.

Conditioning and control assays were performed in a random sequence, one each day. The cumulative number of positive and negative disks picked up in all conditioning and control assays was compared, testing the null hypothesis of a random choice between the two possibilities.

Results and discussion

As Table 1 shows, the positive disks were picked up significantly more often than expected during conditioning assays, while positive and negative impregnated disks were picked up at random during control assays. These results provide strong evidence that *Acromyrmex lundi* workers learn the odors associated with food when they are recruited. Workers were conditioned to the odor of the food fragment carried by the scout worker, and used the learned cue to decide which material should be collected.

Although there are many reports of learned olfactory responses in ants involved in recognition of brood and nestmates (Jaisson 1975; Carlin and Hölldobler 1983; Isingrini et al. 1985), food odor learning during recruitment has not been previously reported.

Laden *Atta cephalotes* workers returning to the nest often transfer their loads to other recruited ants, or carry the loads only as far as the main foraging trail where they drop them (Hubbell et al. 1980). Moreover, a leaf-

Table 1. Cumulative number of *positive* (impregnated with the same odor used to impregnate the food source) and *negative* (impregnated with another odor) filter paper disks picked up by recruited workers during conditioning ($N=10$) and control ($N=10$) assays

	Cumulative number of positive disks picked up	Cumulative number of negative disks picked up	G_T[a]	P
Conditioning assays	88	12	76.88	<0.005
Control assays	53	47	6.95	NS

[a] G_T values from heterogeneity G-test (Sokal and Rohlf 1981). *NS:* not significantly different from ratio 1:1 ($\alpha=0.05$)

marking pheromone, reported for this leaf-cutting ant species, seems to regulate leaf transport from the cutting site to the nest, by increasing the probability that a fragment will be picked up and carried (Bradshaw et al. 1986). Conditioning to food odors in recruited leaf-cutting ants would speed up the decision-making system involved in the foraging process: a decision is made using the learned odor cue instead of evaluating leaf quality. A detailed analysis of the conditioning response of recruited *Acromyrmex lundi* workers will be published elsewhere.

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References

Bowers MA, Porter SD (1981) Effect of foraging distance on water content of substrates harvested by *Atta columbica* (Guerin). Ecology 62:273–275

Bradshaw JWS, Howse PE, Baker R (1986) A novel autostimulatory pheromone regulating transport of leaves in *Atta cephalotes*. Anim Behav 34:234–240

Carlin NF, Hölldobler B (1983) Nestmate and kin recognition in interspecific mixed colonies of ants. Science 222:1027–1029

Cherrett JM (1972) Some factors involved in the selection of vegetable substrate by *Atta cephalotes* (L.) (Hymenoptera: Formicidae) in tropical rain forest. J Anim Ecol 41:647–660

Howard JJ (1987) Leafcutting ant diet selection: the role of nutrients, water, and secondary chemistry. Ecology 68:503–515

Howard JJ (1988) Leafcutting ant diet selection: relative influence of leaf chemistry and physical features. Ecology 69:250–260

Hubbell SP, Johnson LK, Stanislav E, Wilson B, Fowler H (1980) Foraging by bucket-brigade in leaf-cutter ants. Biotropica 12:210–213

Isingrini M, Lenoir A, Jaisson P (1985) Preimaginal learning as a basis of colony-brood recognition in the ant *Cataglyphis cursor*. Proc Natl Acad Sci USA 82:8545–8547

Jaffé K, Howse PE (1979) The mass recruitment system of the leaf cutting ant, *Atta cephalotes* (L). Anim Behav 27:930–939

Jaisson P (1975) L'imprégnation dans l'ontogenèse des comportements de soins aux cocons chez la jeune Fourmi rousse (*Formica polyctena* Först.). Behaviour 52:1–37

Rockwood LL (1976) Plant selection and foraging patterns in two species of leaf-cutting ants (*Atta*). Ecology 57:48–61

Sokal RR, Rohlf FJ (1981) Biometry, 2nd edn, Freeman, San Francisco

Waller DA (1982) Leaf-cutting ants and live oak: the role of leaf toughness in seasonal and intraspecific choice. Ent Exp Appl 32:146–150